

Combining academic education with soft skills development: some common aspects of educational preparation of IT professionals and schoolteachers

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Abstract—In the modern educational process aimed on preparing professionals in the applied areas, it's crucial, along with purely professional training, to provide students both with solid theoretical background and help them to develop "soft skills" that will facilitate their smooth and efficient adaptation to the industry realities when they start their professional careers. In this paper we consider practical cases of acquiring soft skills through intensive field experience in two areas related to mathematical education.

Keywords—education; mathematics; IT

I. INTRODUCTION

In the modern educational process aimed on preparing professionals in the applied areas, it's crucial, along with purely professional training, to provide students both with solid theoretical background and help them to develop "soft skills" that will facilitate their smooth and efficient adaptation to the industry realities when they start their professional careers. In this paper we consider practical cases of acquiring soft skills through intensive field experience in two areas related to mathematical education. The first area is preparation of qualified computer programmers and IT managers, and the other - preparation of schoolteachers specialized in teaching math. The paper continues research described in [1] that stems from a long-term cooperation between St. Petersburg State University, Russia, and State University of New York (SUNY), United States, through which several common aspects of educating mathematicians to work in an IT company as software developers or managers and prospective teachers to work for a technology-rich classroom were identified. The above-mentioned educational commonalities can be described in terms of the signature pedagogy construct - the "types of teaching that organize the fundamental ways in which future practitioners are educated for their professions" [1, p. 52]. In the modern world, when technology penetrates every aspect of human life, many basic principles used in

educating highly qualified workforce of the future have to be revisited. One such revision concerns the need to bridge theory and practice. In the context of preparing computer programmers, it was observed that those students who have experience working as an apprentice for an IT company have come to possess a high level of appreciation of theoretical courses that deal with the issues of governance of IT projects and the quality of the development of programming products. By the same token, when the methodology of teaching courses are taught to teacher candidates who concurrently participate as interns in the life of K-12 schools, their grasp of current signature pedagogies of different content areas becomes much more meaningful and profound allowing for a true intellectual growth of all parties involved in the process of education.

II. ADMINISTRATIVE FLEXIBILITY PRINCIPLE IN CONNECTING THEORY TO PRACTICE

The St. Petersburg State University Mathematics and Mechanics Faculty Department of Applied Cybernetics is the major contributor to the cooperation in research between the two universities. The idea of considering tight cooperation between the University and world-class IT companies working in St .Petersburg as an immanent part of the process of preparation of young IT professionals, was initially formulated shortly before formation of the Department in 2007, and the original approach integrating theoretical courses and field experience of mathematics students was first implemented with a group of 3rd-year students of the Department. The initial experience of the implementation of such collaboration clearly demonstrated the critical importance of full administrative and organizational support of the innovative initiative from University side. Administrative support was strongly needed for solving such problems as coordination of schedule between practical field trainings and regular University

lectures, making field practice mandatory for students and some others typical problems arising within collaboration between University and various industrial IT companies/

Note that in the area of IT education, there is a permanent gap between profile of graduate students and profile of industry companies' requirements to junior IT professionals. This gap is fundamental and caused by two basic reasons. First, the innovations and modifications occur rapidly due to expeditious developments within the field. Second, the majority of students start their first job without possessing necessary soft skills - such as communication, presentation, teamwork skills etc. So, they are forced to acquire these skills just on their workplaces, in process of interaction with their colleagues and managers that causes additional difficulties and discomfort for both sides. These problems can be avoided by enabling students to master these soft skills even during the learning process, through intensive field practice.

Administrative flexibility principle, that this paper emphasizes, implies unconditional support from the administration in the development of new theoretical courses and materials for discussion groups, as well as the elimination or significant revision of outdated courses. Such change requires the need to use a workable blend of a small group of regular faculty members and a much larger pool of part-time faculty with diverse qualifications and expertise in key areas of computer science.

The SUNY Potsdam School of Education and Professional Studies (a school approaching the bicentennial of teacher preparation) is another major contributor to the joint research work of the two universities in the area of mathematics and computer education. The School provides prospective teachers with multiple opportunities in advancing their technological expertise, including active participation in research projects on the use of computers in a mathematics classroom [3, 4]. The rapid development and continuous upgrade of educational software including content-specific as well as generic applications makes it necessary to constantly revise methodology courses in order to reflect changes in technology and the revision of standards for teaching with technology. However, unlike the case of the Department of Applied Cybernetics located in the second largest city of Russia, Potsdam, like the many other school of education sites in the U.S., is located in a rural area. Nevertheless, the technological equipment of the School is as rich as in any other place in the country. Likewise, K-12 schools in the area have state-of-the-art computer laboratories and regular classrooms. In the context of educating prospective teachers, this raises the issue of not lagging behind the ever-changing technological environment available to schoolchildren. The role of the educational administration in facilitating and encouraging faculty-student collaboration in the context of professional development school is also critical.

III. ADMINISTRATIVE FLEXIBILITY PRINCIPLE AND THE PREPARATION OF SOFTWARE ENGINEERS

Consider several examples of administrative flexibility in revising theoretical courses to address practical demands. One example concerns learning Java programming language by mathematics students. Now Java is one of the most commonly used programming platforms, especially in business applications development. Such situation is largely formed through an extensive ecosystem of Java-based industrial technologies grown during the last decade. Therefore, comprehensive knowledge of Java language as well as familiarity with appropriate industrial Java-based technologies is a must for the future software engineers. In the Department of Applied Cybernetics the process of studying Java and Java-based technologies was organized in two basic directions. Within the first direction, Java language basics are studying within both theoretical and practical courses. The theoretical course is taught by Prof. Safonov, Head of Java Technologies Laboratory of the Mathematics and Mechanics Faculty and renowned scholar in this field [5, 6]. The relevant practical course that allows to master the techniques of practical Java programming, is offered by one of the authors of this paper, Prof. N. Kuznetsov. The second direction is a synthetic one-year course titled Introduction in Java/J2EE Business Programming that is delivered by the representatives of Exigen Services, one of the IT companies with which the department cooperates. The course is taught by company specialists and experts having extended industrial experience, on the site of the company and takes the whole day (6 academic hours) every week. All these courses (theoretical and practical basic Java course and course on Java business programming) are delivering simultaneously for the same students, so accurate coordination between them is extremely important. Obviously, such coordination would be impossible without strong support of faculty administration.

One of main goals of business programming course, along with studying new technologies, is to provide students with feelings of specifics of practical work on real industrial projects as well as development of necessary soft skills. Learning Java programming in industrial project-like mode using real infrastructure and actual managing techniques makes studies highly efficient because the learner can acquire both technical knowledge and necessary soft skills. In the words of one participant of the first run of Java courses held in 2007: "It was quite fascinating – because, first, we have learned lot of new technologies that are using by software engineers just now, and, second, we've got strong feeling of "how things are done" in modern global IT companies".

Other examples concern the development and teaching of courses in the critical areas that lie at the border between IT and mathematics. Below is a brief description of such courses and references to the major publications by their instructors. So, Prof. Kiyayev-Deputy Director of St. Petersburg State University Research Institute for IT, has been teaching the course Management Aspects of Metrology, Standardization, and the Quality of Software Development. The course Theory

of Filtration of Random Processes is taught by Prof. Matveev, an expert in the theory of optimization [7, 8]. A course on financial management is taught by Prof. Vavilov who is an expert in portfolio investment control [9]. Most recently, Prof. Koznov, using collaborative learning techniques based on mind maps and Comapping toolset [10], started teaching a course on special topics in software engineering. The flexibility of administration in making personnel decisions when creating such a highly qualified team of adjunct professors cannot be underestimated.

IV. MOTIVATION AND INTERNSHIP

In the context of the collaboration model described above, there is a problem related to the time gap between studying courses combined with field practices (3rd year) and the moment when the students are able to join IT company as full-time junior developers (end of 5th year). During annual course at 3rd year, students have rather strong motivation supported by their acquisition of first "real-life" experience, and it is vitally important not to lose this motivation until the moment when the students come to their first jobs in IT companies. For this purpose, a model of internship is used by the companies – partners of the University. Students who have performed well during their studies and attracted attention of their curators from company side, are invited to become an interns – i.e. participate in real company projects within project developers' teams. The students work for a company part-time so that they can combine their internship with regular University studies. After graduation from the University, those interns who proved their usefulness for the company, are promoted to full-time positions within the company. Students in the department know full well that unless they demonstrate advanced skills during their internship, their chances to continue with the company after the graduation are very slim.

A similar situation can be observed in the context of preparing teachers at SUNY Potsdam. During their field experience and student teaching, by trying to do their best, teacher candidates acquire deep understanding of intrinsic details of the teaching process and develop necessary soft skills. By result of field practice, they earn respect of their sponsor teachers, admiration of pupils and, as a result, a chance to be offered if not a tenure-track job but at least a stable part-time substituting position which, in many cases, may turn into a better professional opportunity. This is especially true when teacher candidates, utilizing skills gained through on-campus courses, support schoolteachers and their pupils in using computers either in a regular classroom or during small-group after-school projects. Here, however, an opposite effect than in an IT company can be observed. Practicing teachers, especially at the primary level, are not always experts in using modern software products and they welcome any help they can receive from the interns and student teachers whose, often superior, technological competence is due to their university preparation in this area. As a 2nd grade (veteran) teacher put it, "Most beneficial to me was the opportunity for a select group of students to be involved in a technology project/activity which I would not be able to offer. Technology is not strength of mine, so I welcome opportunities from others for enriching my students'

knowledge" [3, p. 250]. And these "others" also know full well that school administration, when making a hiring decision, always gives preference to a candidate with advanced skills in using various software tools in the classroom.

V. THE ROLE OF THEORETICAL PREPARATION

The modern IT industry can be characterized by high degree of specialization when the professionals working in one narrow field often don't know about methods and approaches used in the other fields. Thus, a wide professional outlook becomes a major competitive advantage that allows IT professional to find non-trivial approaches and solutions that lie on the border between different areas. Even more important is the presence of strong mathematical background that can be useful not only for from point of improving young professionals' abilities to solve ongoing problems, but also can be used by their hosts for improving quality and reliability of their products.

Here is an example. It has been since the post Second World War period, due to Wiener's [11] seminal book on cybernetics, then a new concept, that the following paradigm gained widespread recognition and acceptance: any mathematical algorithm has an equivalent representation through the elements of electronics. It turned out, however, that in many cases of well-described algorithms underlying the cybernetic synthesis, an object controlled by a simple (or complex) algorithm exhibited an unreliable performance despite all seemingly accurate theoretical and practical predictions. It was then found that the reason for the ill behavior of controllable objects (which often simply go astray) was due to the instability phenomenon. This led to the need to study this phenomenon in rigorous mathematical terms.

Although mathematicians have been developing the theory of instability of control systems from the beginning of the last century, the importance of this theory in the practice of management and control was recognized only in the 1990s. In particular, as recent studies indicate [12, 13], the instability theory proved having the major impact on economics. Thus, in addition to the first backbone of cybernetics, the Principle of Synthesis and Design, the Stability of an Algorithm has become the second backbone of the modern cybernetics.

That is why it became the necessity to revisit educational programs in the Department of Applied Cybernetics towards the end of introducing students to the modern theory of dynamical systems emphasizing topics dealing with the problems of stability and instability of the algorithms of control. Consequently, a new theoretical construct called the dynamical management was developed by one of the authors of this paper [14]. Put another way, dynamical management can be defined as control with provision for instability. The dynamical management construct enables one to appreciate

the fact that the application of methods, results, and concepts of cybernetics that were developed primarily for engineering systems, can bear fruit in the study of many other systems (including social ones) where instability effects can be observed. Augmenting the modern theory of dynamical systems [15], the concept of control with provision for instability is now included as an important element of the theoretical preparation of future software engineers.

The need for a theory in the preparation of prospective teachers can also be supported by an example. An active participation of pupils in classroom discourse is one of the main characteristics of the modern signature pedagogy of school mathematics. In general, signature pedagogies being "pedagogies of uncertainty ... render classroom settings unpredictable and surprising, raising the stakes for both students and instructors" [1, p. 57]. Put another way, a phenomenon of instability of a kind may be observed in the classroom, especially when pupils are encouraged to ask questions about mathematical situations which may or may not have easy answers. So, a student teacher was observed attempting to answer a question asked by a primary grade pupil as to how many ways can five rings be put on five fingers. In fact, this question, connected to pupils' use of an electronic spreadsheet in exploring outdoor temperature changes [4], was asked after it was found experimentally that there are six ways to put five rings on two fingers. The teacher didn't suspect that the right answer, even if found, would be way too beyond young children's grasp and ability to verify through a hands-on activity. As a result, the question was left without a proper answer and a seemingly stable equilibrium of the pupil's interest towards mathematics was in danger of bifurcating into an unstable one. In order to provide teacher candidates with experience in distinguishing between questions that have and that do not have easy answers, something that can help them to avoid undesirable instability of the classroom discourse, a special mathematics content course for primary teachers was developed and has been offered each semester at SUNY Potsdam. The above two examples, borrowed from different educational settings, demonstrate how practice motivates the need for the theoretical preparation of both prospective managers of IT projects and companies and prospective schoolteachers of mathematics and perhaps other subjects.

VI. EDUCATIONAL MOBILITY IN THE CONTEXT OF FIELD PRACTICE

New tendencies in education associated with global mobility take the effect on the preparation of managers for IT companies as well as teacher candidates capable of navigating within the ever-changing market of modern technologies and tools. As a member of the global educational network, a student can take and get credits for a course (or courses) through either an official program or at his or her own initiative.

Regarding field practical activities, the educational mobility is quite useful for students because it allows them to experience a wide variety of possible types of either IT companies or schools - possible places of their future work. In particular, teacher candidates may select another US state or even a foreign country as a site for their semester-long student teaching experience. Far away from home, they can learn how to teach in an environment alien to them, how to use previously unknown software tools or recommend to their host school something they are familiar with through earlier field experiences or on-campus technology-rich courses. Obtaining learning experience from different universities or from far-off internship sites increases educational mobility of students.

In the case of preparing IT professional with intensive field training in IT companies, educational mobility is implemented through encouraging students to get familiar with various types of companies. In particular, it is done through short-term practices in such companies organizing on the project base. During such practices, students are united into one or more project teams that should develop some simple software product "from the scratch" to stable alpha version during 2-3 weeks working 4-6 hours per day. The intensive work inside project team lets students to quickly acquire soft skills specific for given company type.

VII. COLLABORATION BETWEEN IT COMPANIES AND THE UNIVERSITY: EXAMPLES

As an illustration of useful and efficient collaboration between the University and industrial IT companies, let's consider two examples. The first example describes collaboration with St. Petersburg R&D Center of Informatica Corp - a US-based international company working in the area of data integration. Another example describes collaboration with Exigen Services - US-based company specialized in the area of business software development.

Informatica Corp is an international company, with headquarters in Redwood City, California. It is a recognized independent leader in data integration, with offices in more than 60 countries employing over 2500 people. The program of collaboration between the company and St. Petersburg State University started in 2011 as a result of the joint initiative of two authors of this paper, S. Kuznetsov-Head of Informatica R&D Center in Russia and G. Leonov-Dean of Mathematics and Mechanics Faculty.

Informatica Corp has been running university collaboration programs in the U.S., Russia, and India. The Russian program was localized at St. Petersburg State University, given an excellent theoretical background of its students in fundamental sciences such as pure and applied mathematics and computer science.

The main focus of the program is to prepare undergraduate, graduate and post-graduate students for the industrial software product development, and to give them more information about technologies involved, development methodologies, and industrial product lifecycle. Also, the program provides a prospective junior staff member with clear understanding of different professional positions at an IT company varying from software and quality engineering positions to product management supervisor, clientele representative, customer satisfaction personnel, etc.

The collaboration between St. Petersburg State University and Informatica Corp is beneficial for the students from multiple perspectives. They enhance their scientific and technical background with real-life examples of commercial business programming, learn to adapt to the culture of a large enterprise software company, augment their knowledge in big data governance – one of the most growing areas of IT. The University provides students with a flexible schedule of studies allowing them to spend a full day at the company site. This, in particular, helps one to become familiar with multiple routines and practices of the company that is crucially important for the development of the soft skills.

Exigen Services is a US-based global IT company with headquarters in San Francisco, California, that delivers services in the area of business software development for large US and European clients from different business verticals - banking, finance, insurance, telecom and others. Exigen Services has its offices and R&D centers in many countries worldwide - including US, CIS countries and China. The cooperation between Exigen Services and the Department of Applied Cybernetics has been started in 2007, soon after foundation of the Department. The collaboration program was a result of joint effort of company top management and one of the authors of this article, G.Leonov - Dean of the Faculty of Maths and Mechanics. The joint academic program includes two main directions: first, company experts deliver one-year mandatory course "Introduction to business programming in Java/J2EE" for 3rd year students. Second, regular practical trainings are performed for University students on company sites. The main goal of both kinds of activities is providing deep immersion of the students into real industrial atmosphere that allows them to master new cutting-edge technologies and acquire necessary soft skills. Such approach is closer to business school-like methodology rather than purely academic one.

Both companies offer internship opportunities for the students who demonstrated good results and high motivation during lectures and practical courses. Interns work on real customer projects conducted in the company on part-time basis; their working schedule is coordinated with University studies. After some time of internship, depending on their efficiency and overall economic situation in the company, interns may get offer for either permanent part-time or full-time positions within the company. As a rule, young people are moving at

company employee positions during 5th year when the workload in the University is getting lower.

The figures demonstrating the dynamics of cooperation between the Department of Applied Cybernetics and two mentioned IT companies are shown in Table I (values in the cells mean number of students passed through the program):

TABLE I

	2010	2011	2012	2013
Exigen Services - Lectures	22	25	24	25
Exigen Services - Practices	14	20	22	25
Exigen Services - Interns		5	7	10
Informatica - Practices	18	15	15	15
Informatica - Interns		3	5	5

VIII. ANALYZING VOICES FROM THE FIELD

The evaluations of the students' fieldwork by their hosts (some of which were shared above) are valuable means used in the process of deciding the improvement of academic programs. Equally important are students' reflections on the field experience component of their studies. Thus it is essential to solicit such reflections as appropriate. By analyzing voices of both parties, one can make an informed decision about various aspects of comprehensive curricula as far as the improvement and the revision of theory and practice are concerned. In the context of preparing mathematicians, the students' opinion of theoretical preparation as a vehicle for advancing practical aspects of software engineering has to be taken into account in at least two ways: either to make the appropriate revision of a theoretical course or try to develop a better appreciation of theory by students through the use of carefully chosen examples emphasizing the role of formal knowledge in applications.

The most common praise of the educational approach to the preparation of computer programmers highlighted in the paper is the opportunity to work on real projects as a team member. As one of the post-graduate students of the Department of Applied Cybernetics, underscoring both the value of theoretical and practical preparation through the University collaboration with Exigen Services company, put it: " I had a year-long internship with Exigen Services. It allowed me to gain a valuable experience of participation in a real project and acquire skills of working as a team member. While at the company, I had a chance to utilize theory studied at the university as well as augment my theoretical background with new knowledge. I'm confident that my experience working at

one of the major IT companies would be appreciated by my potential employers in the future".

Another doctoral student in the department was even more positive about her internship with Exigen Services, highlighting, in addition to the learning experience, the social aspects of fieldwork. In her words: "Practical skills are always important for a student to acquire towards the end of using them in the future professional work. However, not many companies offer internship opportunities to a student. At the same time, without experience it is difficult to be hired by a reputable company. Through my internship with Exigen Services I gained priceless experience of being involved in solving real problems. As a team, we worked on a project that required from me to study tons of new information. My supervisors always helped me to overcome difficulties and assisted with the clarification of any intricate matter. Last but not least, the internship with Exigen Services was not only work and study but also an opportunity to get to know interesting people".

Reading the above two reflections allows one to conclude that the role of the Department of Applied Cybernetics was critical in establishing collaborative relationships with major IT companies. Obviously, the students would not have been able to develop such contacts by themselves. Also, one can see how the administrative flexibility principle, which works nicely in a university setting, can be extended beyond formal schooling to make students feel "confident" in their skills and abilities and see their field experience as "priceless". Ultimately, having such a strong trust in the quality of their preparation allows the students to enter the ever-challenging modern job market of highly qualified workforce with a sense of self-competitiveness.

In the context of professional development school, one of the avenues in advancing teacher candidates' soft skills is to offer an opportunity to see a classroom as a site for inquiry and participate in the so called action research under the supervision of their professors. Consequently, teacher candidates who take advantage of this opportunity are encouraged to present their finding at professional conferences, in particular those, devoted to the use of computers in education. Teacher candidates who choose to respond positively to the call for doing action research, although feel little bit overwhelmed, eventually have high appreciation of their "extra" work. As mentioned by one of the teacher candidates who was sharing her experience of using spreadsheets with young children at a professional meeting: "The conference went well... people were interested in the spreadsheets the most, and how the students responded, of course. We were the only elementary age level research there - most of the conference [sessions] targeted college level research - and many situations were hypothetical, so we definitely added to the diversity of the conference. All in all I have been very happy with my decision to do research: it has given me a great experience and has really helped set me apart during job interviews" [3, p. 256]. Indeed, as was mentioned above, a teacher candidate with advanced soft skills (including

computer skills) is always the preferred contender for a full-time teaching position.

IX. CONCLUSION

The analysis of teaching young professionals in two seemingly different directions, described in this paper - future software engineers and IT managers, on the one hand, and future math teachers, on the other hand - clearly shows all the importance of combining basic applied education with both solid theoretical knowledge and advanced soft skills. The most efficient way of proper soft skills development is intensive field experience. The paper describes authors' practical experience in conducting field activities for students of Saint-Petersburg State University and State University of New York. It is hoped that the ideas shared in this paper and the authors' unified pedagogical perspective on the development of students' soft skills can be used by diverse professionals-mathematicians, teacher educators, managers of IT companies-around the world.

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